JS Army Corps
of Engineers
North Central Division

GREAT LAKES LEVELS

Update Letter No. 80 March 3, 1992

Zebra Mussels

INTRODUCTION

Zebra mussels are a freshwater bivalve native to the area near the Black Sea in Europe. The adult mussels grow up to 5 centimeters in length, and live 3 to 5 years. Their shells are angular and are usually striped with alternating bands of brown and yellow, although a wide range of patterns occur. The sexes are separate, and fertilization is external. Reproduction occurs when the water warms up in spring, although mussels living in warm-water effluents from industrial plants may reproduce during the winter. Each female sheds up to 40,000 eggs into the water, which are fertilized by sperm released synchronously by males. The eggs hatch within hours into 60 micrometer larvae resembling microscopic clams. These larvae drift passively for up to 4 weeks, or until they are 180-250 micrometers, after which they settle onto hard substrates. Once a suitable location is found, the larvae extrude sticky threads called byssus with which they attach themselves to the substrate. Attached zebra mussels are difficult to displace, due to the strength of the byssal attachment, but they can voluntarily detach from the substrate and move around using their muscular foot.

Zebra mussels *(Dreissena polymorpha)* are marble-size, barnacle-like freshwater mollusks that colonize almost any underwater structure with a hard surface, including water intake pipes, boat hulls, harbor pilings, navigation buoys, and commercial fishing gear. Colony densities range up to hundreds of thousands per square yard.

Zebra mussels first began to spread from their native range in the 1700's by accidental transport on boats navigating between the Caspian Sea and western Europe. They were found in Hungary in 1794, in Britain in the 1820's, in the USSR in 1845, and in Italy as late as the 1970's. They were first noted in North America in Lake St. Clair in 1988, having probably arrived in 1985 or 1986 in the ballast water of an ocean tanker. Their range expansion in North America has occurred in two manners; downstream, by passive transport, and both upstream and downstream by man-mediated transport. Possible methods which enhance the spread of the mussels include adult attachment to boat hulls, larvae transport in bilge water and bait buckets, dumping of aquaria into which mussels have been introduced, and fish stocking by state and federal agencies. By 1990, the mussels were present in all of the Great Lakes and the New York State Barge Canal. By 1991, they had

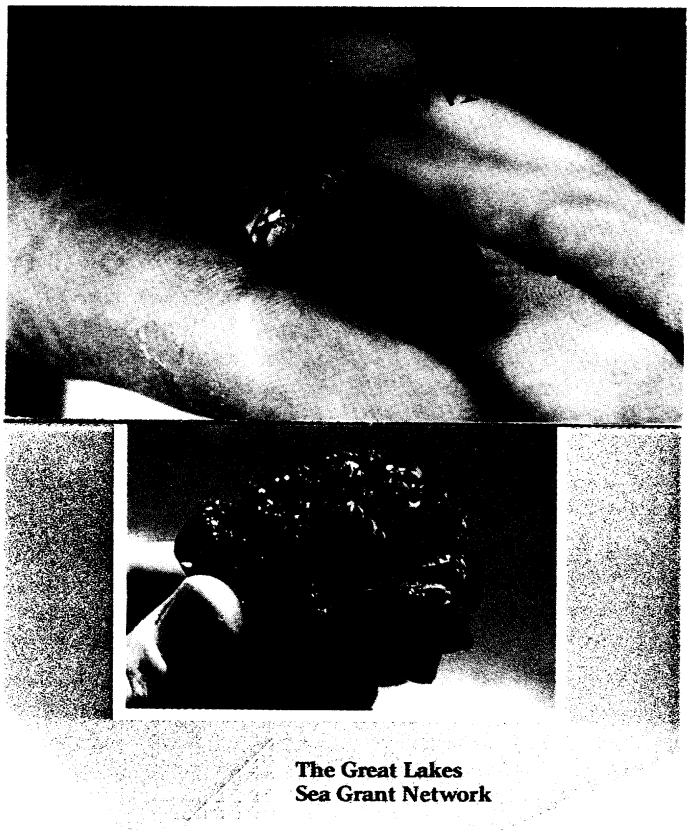


Figure 1. Zebra Mussel Watch Card.

been found in inland lakes; Oneida and Cayuga in New York, Muskegon Lake in Michigan, and Indiana Lake in Ohio. At this point their spread through the North American river drainages is inevitable, as water currents will transport them freely and man will transport them inadvertently. Zebra mussels have been found in other inland waters, including the Hudson River, the Susquehanna River, the Finger Lakes (New York), the Illinois River, the Mississippi River, the Ohio River, the Missouri River, and the Tennessee River. (See Figure 2). Events in Lakes St. Clair and Erie indicate this organism has tremendous destructive potential. It is also clear that massive infestations can occur with little warning, since the zebra mussel was virtually unknown in the Great Lakes just 4 years ago.

Lakeside power plants, industries, and municipalities with water intakes in the nearshore region are likely to suffer the most serious and costly encrustations. One Great Lakes' water utility has estimated that it may cost several million dollars a year to scrape the mussels from its intakes, and many Great Lakes water intake pipes may have to be redesigned to provide more access points for monitoring and removing the mussels. Possible controls include the use of intake screens, electrostatic filters, flushing with hot water, and chlorination. In some cases it may be necessary to install secondary intake pipes, so the primary pipes can be shut down for cleaning.

A number of potential problems at Corps' navigation structures have been identified. The concrete and steel surfaces of the lock and dam structures may provide the firm surface to which the zebra mussels attach. At thicknesses of 1 to 2 inches, the mussels could begin to cause problems at sealing surfaces of lock and dam gates. The increased weight from matted colonies of mussels may also affect the functioning of dam gates. Of concern are sealing surfaces of dam gates and intakes for lock filling systems. Commercial and private navigation facilities would similarly be affected.

Zebra mussels are predicted to have significant impacts on both the aquatic ecosystem and on human water users. Feeding by millions of these mussels, which can each filter over a liter of water per day, threatens to deplete the population of microorganisms, the base of the aquatic food chain. Ultimately, this depletion could reduce forage fish populations and threaten the health of the sport and commercial fisheries. The excretion of pseudofeces into the sediments may reduce benthic-dissolved oxygen during decomposition. Lake trout and walleye spawning areas are at risk due to clogging of interstitial spaces by dense colonies of mussels. To date, however, none of these anticipated effects has been documented. Some of the following changes in fish diets have been noted: freshwater drum, carp, and yellow perch have been caught with zebra mussels in their stomachs, and young yellow perch appear to benefit from the increase in macroinvertebrate populations which feed on pseudofeces. The most obvious and immediate effect of the mussels on native species has been due to the attachment of zebra mussels onto the shells of native mussels, clams, snails, and crayfish. Crayfish can be rendered immobile and unable to shed by large numbers of mussels on their carapace. Dense settlement of zebra mussels on native clams and mussels can result in growth deformities, suffocation, or starvation due to competition for food.

The most severe impacts of zebra mussels have occurred in industries and public utilities with water intakes in the Great Lakes. For example, the water treatment plants in Monroe, Michigan, suffered a 60-percent loss of water delivery in 1989, due to mussel infestation. The Detroit Edison Power Plant in Monroe manually removed 40 cubic meters (10 metric tons) of mussels from water intake structures in 1989. This cleanup took 8 days and cost $25,000. The implementation of control methods, such as mechanical cleaning or chemical treatment, involves considerable cost, especially when retrofitting is involved. Prophylactic chemical treatments to prevent settlement of veligers can cost up to $1,000/day. One-time treatments to kill settled adults can have deleterious consequences, as dead mussels are suddenly released en masse into the water pipes. For example, the Burns Harbor Bethlehem steel plant in Indiana suffered a 50-percent plant shutdown for 2 days, when dead mussels clogged their small-diameter pipes which provided blast-furnace cooling water.

Despite the "horror story" coverage zebra mussels have received lately in the news media, Europeans have coexisted with zebra mussels for nearly 2 centuries. But the immense expense, disruptions, and inconveniences that they may cause here are a legitimate concern not only for the Great Lakes region, but other lakes and waterways of our Nation.

Since 1988, when zebra mussels were first discovered in Lake St. Clair, the Sea Grant Programs of several states in the Great Lakes' Basin have been involved in identifying these small mollusks as potentially harmful to the region.

This potential environmental and economic damage was quickly realized when zebra mussels began clogging up intake pipes in water treatment, utility, and manufacturing plants at numerous locations across the Great Lakes.

The impact eventually spread to boaters and marina owners, who needed to find ways of removing the mussels from boat hulls, piers, and buoys. Many buoys became so encrusted with mussels that they sank.

Shorelines have become littered with dead mussels, and their sharp shells have made a simple barefoot walk along the beach a hazardous undertaking. Also, the smell of large numbers of dead and rotting mussels is enough to ruin any family's day at the lakefront.

As the zebra mussel invasion has expanded, so too has the cost to control them. Industry groups, such as the Empire State Electric Energy Research Corporation (ESEERCO) and political representatives from throughout the region, have sought funding to undertake research and information efforts.

As part of this region-wide information effort, the Sea Grant Programs from several of the Great Lakes' states have formed a network of Zebra Mussel Information Centers and Clearinghouses. This article has been developed to provide the public, industry, and local officials with a current overview of how far the zebra mussels have spread, recommended control approaches, and whom to contact in your area for further information.

Because of the dynamic nature of this problem, the reader is advised that the information contained in this article

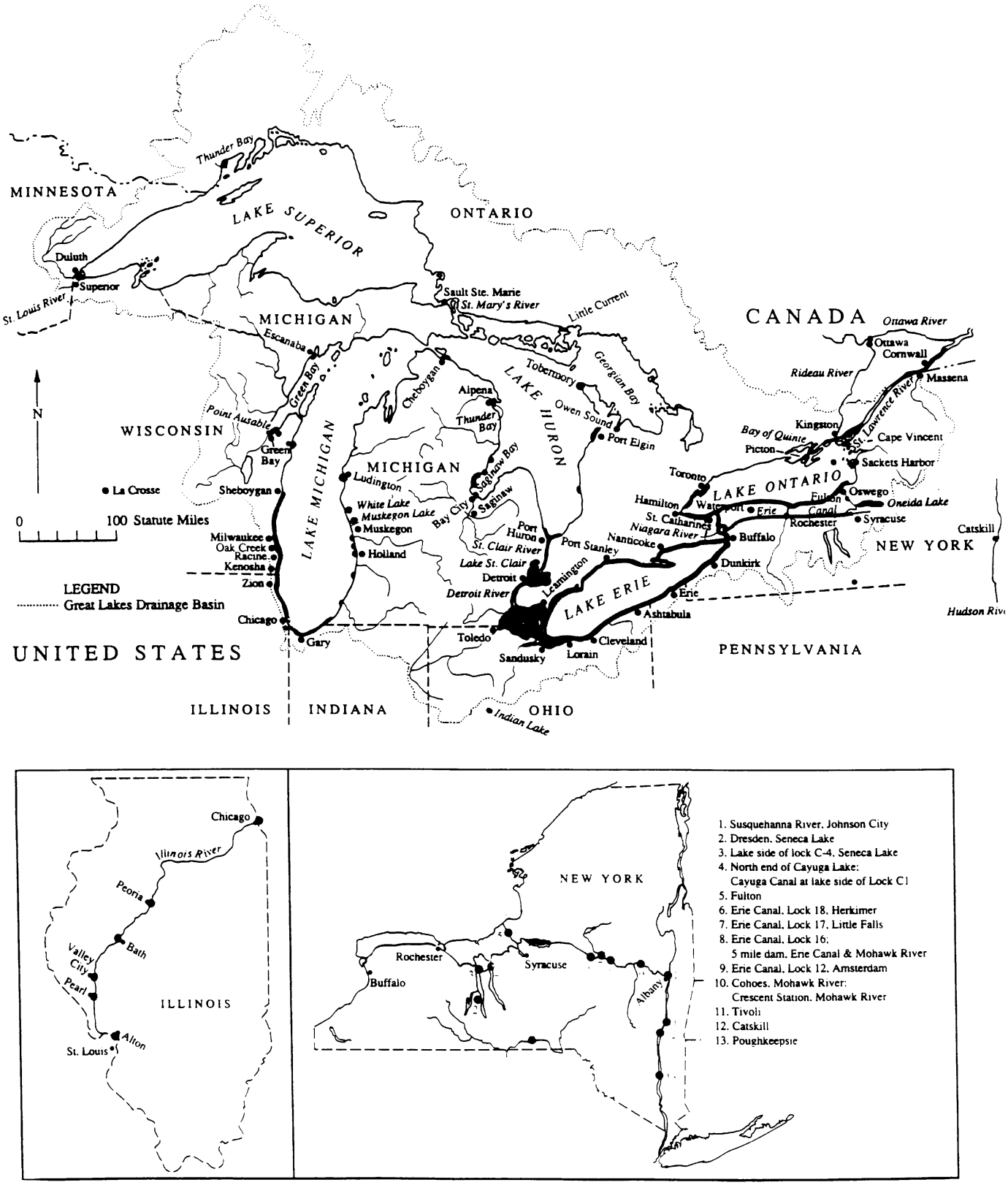


Figure 2. **North American Range of the Zebra Mussel**

Great Lakes Basin Hydrology

The precipitation, water supplies, and outflows for the lakes are provided in Table 1. Precipitation data include the provisional values for the past month and the year-to-date and long-term averages. The provisional and long-term average water supplies and outflows are also shown.

Table 1
Great Lakes Hydrology[1]

PRECIPITATION								
BASIN	FEBRUARY				YEAR-TO-DATE			
	1992*	AVG.**	DIFF.	% OF AVG.	1992*	AVG.**	DIFF.	% OF AVG.
Superior	1.2	1.5	-0.3	80	2.7	3.4	-0.7	79
Michigan-Huron	1.4	1.7	-0.3	82	3.2	3.8	-0.6	84
Erie	2.0	2.1	-0.1	95	4.5	4.5	0.0	100
Ontario	1.7	2.4	-0.7	71	4.2	5.1	-0.9	82
Great Lakes	1.5	1.8	-0.3	83	3.3	3.9	-0.6	85

LAKE	FEBRUARY WATER SUPPLIES***		FEBRUARY OUTFLOW[3]	
	CFS[2]	AVG.[4]	CFS[2]	AVG.[4]
Superior	7,000	10,000	80,000	67,000
Michigan-Huron	97,000	88,000	174,000[5]	154,000
Erie	46,000	35,000	197,000[5]	188,000
Ontario	27,000	37,000	225,000	223,000

*Estimated (inches) **1900-90 Average (inches)
***Negative water supply denotes evaporation from lake exceeded runoff from local basin.

[1]Values (excluding averages) are based on preliminary computations.
[2]Cubic Feet Per Second [3]Does not include diversions [4]1900-89 Average (cfs)
[5]Reflects effects of ice/weed retardation in the connecting channels.

For Great Lakes basin technical assistance or information, please contact one of the following Corps of Engineers District Offices:

For NY, PA, and OH:
Colonel John W. Morris
Cdr, Buffalo District
U.S. Army Corps
of Engineers
1776 Niagara Street
Buffalo, NY 14207-3199
(716) 879-4200

For IL and IN:
LTC Randall R. Inouye
Cdr, Chicago District
U.S. Army Corps
of Engineers
River Center Bldg (6th Flr)
111 North Canal Street
Chicago, Il 60606-7206
(312) 353-6400

For MI, MN, and WI:
Colonel Richard Kanda
Cdr, Detroit District
U.S. Army Corps
of Engineers
P.O. Box 1027
Detroit, MI 48231-1027
(313) 226-6440 or 6441

is subject to change.

HAND-TO-HAND COMBAT AGAINST ZEBRA MUSSELS

In an effort to help people deal with these midget monster mussels, the Sea Grant Marine Advisory Service makes the following suggestions:

*Scraping is the currently recommended method of removal, if you have zebra mussels on docks or piers. Be advised that live mussels may be able to reattach to hard surfaces, so the scraped mussels should be caught in a bag or bucket. This is also important if the mussels are dead, because they foul the water and create an obnoxious odor as they decay.

Depending on the degree of infestation, scraping once or twice a month should keep colonies under control. A large buildup should be avoided, because the mussels' waste excretions speed up corrosion of docks and piers.

*When transporting a boat, drain all bilge water, live wells, and bait buckets before leaving infested areas. Leftover bait should not be transported from infested waterways to uninfested waters.

*Thoroughly inspect your boat's hull, outdrive, trim plates, trolling plates, prop guards, transducers, trailers, and other parts exposed to infested waters. "Hitchhiking" mussels should be scraped off.

*Thoroughly flush hulls, outdrive units, live wells (and pumping systems), bilge, trailer frames, anchors and anchor ropes, bait buckets, raw water engine cooling systems, and other boat parts and accessories that typically get wet using **hot** (140 degrees F (60 degrees C) or hotter) water. Using a pressurized steam cleaner or high pressure power washer would also be effective, require less time, and is considered environmentally compatible.

*Boats and trailers should be allowed to dry thoroughly in the sun before being transported to uninfested waterways.

*On boats that remain in the water, mussels can attach to the outdrives, covering or entering water intakes and resulting in clogging, engine overheating, and damage to cooling system parts. Mussels on and around props and shafts can increase drivetrain wear. If possible, avoid leaving outdrives in the down position. Hulls and drive units should be inspected and scraped free of mussels.

*Antifouling paints may be effective in preventing attachment of zebra mussels to boat hulls, outdrive units, propellers, and other underwater boat components and accessories. Consult with your local marine dealer or manufacturer for applicability and local use or environmental restrictions. Hull waxes do not appear to be effective.

*When going to the beach, make sure that you take sandals or some other kind of footwear. Broken zebra mussel shells are very sharp. Before you settle in, inspect the beach site and take precautions if you find mussel shells.

*Town and county governments working with citizen volunteers are forming beach patrols to aid in monitoring the presence of the mussel shells and other debris.

This is just a brief overview of some of the control methods that are currently available or are being explored.

For additional information, wallet-size Zebra Mussel cards are available through the Great Lakes Sea Grant Network (Figure 1). The card features photos of the mollusk, briefly describes its distinguishing traits, and tells you what to do if you find one. These cards are available from your state's Sea Grant Office, either individually or in bulk. The prices vary by Sea Grant Office, ranging from free to about 10 cents for each card. Bulk prices, however, may be lower. To get these cards or other information about the Zebra Mussel, the addresses and telephone numbers of the Sea Grant Offices are provided below.

Illinois/Indiana Sea Grant
Sea Grant Communicator
65 Mumford Hall
1301 West Gregory Drive
Urbana, IL 61801
Phone: (217) 333-9448

Michigan Sea Grant College Program
2200 Bonisteel Boulevard
University of Michigan
Ann Arbor, MI 48109-2099
Phone : (313) 764-1138

Minnesota Sea Grant
1518 Cleveland Avenue, North
Suite 902
St. Paul, MN 55108
Phone : (612) 625-1253

New York Sea Grant
Swetman Hall
SUNY College
Oswego, NY 13126-3599
Phone: (315) 341-3042

Allen H. Miller
University of Wisconsin Sea Grant Institute
1800 University Avenue
Madison, WI 53705
Phone: (608) 262-0645

Joseph O'Leary
Illinois/Indiana Sea Grant
Purdue University
Forestry Building
West Lafayette, IN 47907
Phone: (317) 494-0409

John Schwartz
Michigan Sea Grant
Michigan State University
334 Natural Resources Building
East Lansing, MI 48824
Phone: (517) 753-9568

Jeff Gunderson
Minnesota Sea Grant College Program
University of Minnesota-Duluth
208 Washburn Hall
Duluth, MN 55812
Phone: (218) 726-8106

Charles R. O'Neill, Jr.
New York Sea Grant
250 Hartwell Hall
SUNY College at Brockport
Brockport, NY 14420-2928
Phone: (716) 395-2638

Maran Brainard
Ohio Sea Grant College Program
The Ohio State University
1314 Kinnear Road
Columbus, OH 43212
Phone: (614) 292-8949

Adult zebra mussels are eaten by diving ducks and some dabbling ducks (scaup, tufted ducks, and mallards), mammals (muskrats), crayfish, and several fish species (freshwater drum, carp, yellow perch, and sturgeon). Coots have been reported to consume as much as 93 percent of the standing crop of adult mussels in local bodies of water in Europe during the winter. The larvae are eaten by adult zebra mussels, and recent research indicates that they may

also be food for gizzard shad. In Europe, newly-established zebra mussel populations typically decline 5 to 10 years after their initial exponential growth phase. These population declines presumably occur due to increased predators and disease organisms and depletion of food resources by the mussels.

INDUSTRIAL-STRENGTH MUSSEL CONTROL

The job of cleaning up zebra mussels will prove to be a daunting task for industries throughout the Great Lakes. Plant managers and environmental control personnel are being called upon to solve this problem in the most effective ways possible. Management implies regulated coexistence, not indiscriminate destruction. There are currently some control methods that seem to be environmentally safe and effective when undertaken by trained and knowledgeable personnel. These include the following:

*Thermal control. Water is heated to 100 degrees F to 110 degrees F (38 degrees C to 43 degrees C) for a minimum of 30 minutes, resulting in the rapid death of most zebra mussels. This treatment should be done three times a year, or as often as local conditions warrant, with the mussel debris removed from the source body of water.

*Chlorination. At the point of raw water intake, chlorination has proved to be effective in controlling zebra mussels. The use of chlorine requires site-specific testing to determine appropriate concentrations. There is concern about the negative effects of chlorine on nontarget species. Therefore, dechlorination at the point of discharge is required.

*Molluskicides. These have proven to be effective in industrial and power plant applications. However, before using chemical treatments, all plant personnel are advised to check with state and local environmental regulatory agencies on their use.

*Organometallic toxicants. These consist of tributyltin oxide or copper coatings that may effectively prevent zebra mussel attachments to surfaces, such as boat hulls and buoys. However, they are relatively expensive, difficult to apply, have a short service life, and may result in negative environmental impacts on nontarget species. Tributyltin coatings have been banned for some uses. Check with local authorities for use restrictions.

*Others. Ultrasonic vibrations are being researched as a control methodology.

Teflon-type nonstick coatings are being tested and may prove useful.

Copper pipe is highly effective in limiting zebra mussel attachment. However, the high costs will probably prevent widespread use in boats and industrial plants.

HAVE YOU SEEN THIS MUSSEL MENACE?

NAME	Zebra Mussel *Dreissena polymorpha*
SIZE	Less than 3 inches.
SHELL	Elongated. The light and dark bands give the shell a zebra-like appearance.
BYSSAL THREADS	Allow the zebra mussel to attach itself to most hard surfaces.
KNOWN HANGOUTS	Pilings of docks and piers; buoys; boat hulls; submerged rocks and other underwater surfaces; intake pipes for utility, water, and industrial plants.
WHAT TO DO	Note the location and approximate quantity of zebra mussels found and report your findings to your local Sea Grant Program.

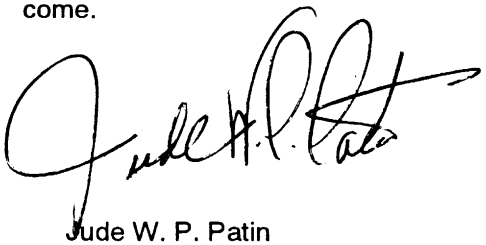
This article is credited to Mr. Phil Keillor of the University of Wisconsin-Madison Sea Grant Institute. The Great Lakes Sea Grant Network is part of the National Sea Grant College Program, which is funded by the National Oceanic and Atmospheric Administration, state legislatures, and industry. Also, credit is given to Dr. J. Ellen Marsden, Illinois Natural History Survey, Lake Michigan Biological Station, for her paper, "Overview of the Zebra Mussel Invasion," October 22, 1991.

BG PATIN'S FAREWELL

On March 31, 1992, I will retire from the U.S. Army after over 29 years of service.

I appreciate your support and the opportunity to serve you over the past few years.

I have thoroughly enjoyed my tour of duty in the North Central Division. I wish all of you the very best in the years to come.



Jude W. P. Patin
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